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NAVORD REPORT 6873
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CAPABILITIES OF EXPLOSIVE LOADING GROUP OF THE CHEMICAL ENGINEERING DIVISION (WE) (U)

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U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NAVORD Report 6873

CAPABILITIES OF EXPLOSIVE LOADING GROUP OF THE CHEMICAL ENGINEERING DIVISION (WE) (U)

By:

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Approved by: _____

D. C. HORNIG, Chief
Chemical Engineering Division

ABSTRACT: The Naval Ordnance Laboratory has, in its Chemical Engineering Division, facilities for making explosive and propellant charges, in many different ways, such as casting, pressing and machining. Due to the dangers accompanying these operations, limitations in quantities and in technique are imposed. Castings up to 45.4 kg. (100 lbs.) and pressings up to 22.7 kg. (50 lbs.) of explosives can be made. Equipment and space limit present propellant mixing to approximately .45 kg. (1 lb.).

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CHEMISTRY RESEARCH DEPARTMENT
U. S. NAVAL ORDNANCE LABORATORY
White Oak, Silver Spring, Maryland

The use of the facilities described in this report is authorized under practically every task assigned to the Chemical Engineering Division including NOL 323, Polaris Sensitivity, NO 301/664/43003/01, Explosions in Water, NO 301/664/43006/08, Explosives Applied Research, and NO 120-61015/91, Sparrow III.

These facilities are an essential adjunct to the development and research work in high energy material being carried on at the Laboratory. They must be capable of producing high quality, reproducible charges, even with materials known to be too sensitive for military use. In addition, they must provide safety for the people who operate them.

It should be pointed out that the rules for safety listed herein are based on experience with conventional explosives and that appropriate adjustments should be made with other materials.

W.D. COLEMAN
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

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CAPABILITIES OF EXPLOSIVE LOADING GROUP OF THE CHEMICAL ENGINEERING DIVISION (WE) (U)

INTRODUCTION

In addition to the research and experimentation assigned to, or initiated by, the Explosive Loading Group of the Chemical Engineering Division (WE) the facilities of this group are very often utilized by other groups in the Laboratory and other government agencies in the area.

It is the purpose of this report to acquaint these units with the facilities and material which are available. Although practically nothing is said regarding the personnel of the Loading Group, it should be understood at the outset that those who make up the group are not only fully qualified, and very skillful in the operation of the equipment, but have had many years of experience in the handling of explosives and allied sensitive materials.

Casting - Building 305

In general, any castable high explosive can be cast in the Naval Ordnance Laboratory facility. Three vacuum, steam heated kettles are available to handle explosive mixtures with melting points up to 100°C to make charges up to 45.3 kg. (100 lbs.) in weight. The Groen 75.7 liter (20 gal.) kettle, Figure 1, has an electric stirrer with speed control. The 30.3 liter (8 gal.) kettle also has an electric stirrer, but the 7.6 liter (2 gal.) kettle has an air operated stirrer with speed control. Due to safety regulations, explosives having an impact sensitivity of less than 30 cm., as determined on the Bruceton drop test machine, Figure 15, should not be cast.

In special cases, where urgency requires, sensitive materials (such as TNETB), can be cast remotely by using a special set-up in the pressing facility.

Among the explosives frequently cast at Building 305 are: TNT, Pentolite, the HBX's, H-6, Composition B, DINA, EDNA, Cyclotol, Octol, Tritonal and Amitol.

Molds are available for cylinders, spheres, slabs, and bars. Also explosives can be cast directly into warheads or other special containers. Mold sizes are as follows:

Cylinders range from 5.08 mm. (0.2 in.) to 28.6 cm. (11.25 in.) in diameter and 38.1 mm. (1.5 in.) to 38.1 cm. (15.0 in.) long.

Spheres range from 4 g. to 28.1 kg. (62 lbs.) weight, based on Pentolite.

Slabs 30.5 cm. (12 in.) long by 15.24 cm. (6 in.) wide range from 6.34 mm. (1/4 in.) to 15.24 cm (6 in.) thick.

Square and rectangular bars are made in the slab molds with spacers.

Special molds are available for casting shaped charges 41.3 mm. (1 5/8 in.) diameter by 15.24 cm. (6 in.) long, plane wave boosters of diameters from 41.3 mm. (1 5/8 in.) to 76.3 mm. (3 in.), lens charges (donors and acceptors) 10.8 cm. (4 1/4 in.) diameter by 15.24 cm. (6 in.) to 25.40 cm. (10 in.) diameter, and tapered charges 0 to 41.3 mm. (1 5/8 in.) diameter by 50.8 cm. (20 in.) long.

Pressing - Hydraulic - Building 318

Two hydraulic presses are available to the Loading Group. The Farquhar 300 ton double acting compacting press, Figure 2, has 76 cm. (30") of daylight between the top ram and the platen. It will provide pressures of from 36,287 kg. (40 tons) to 272,160 kg. (300 tons) on the mold. It has manual or cycle control both directly or remotely. It is equipped with an oil circulating system for heating and cooling the molds, providing temperatures from 10°C to 130°C. A vacuum system provides for evacuating the molds. The heating and cooling system and the vacuum system are common to both presses. Molds for this press are available in sizes from 5.08 cm. (2 in.) to 19.05 cm. (7 1/2 in.) in diameter. The 12.7 cm. (5 in.) mold makes possible the widest range of pressures (281.2 to 2109.2 kg/cm^2 or 4000 to 30000 psi) thereby providing the widest range of densities in the pressed pellets.

The Watson-Stillman 25 ton single acting compacting press has been modified to provide a bottom ejecting ram. Pressures can be accurately obtained from 4,536 kg. to 22,680 kg. (5 to 25 tons) on the mold. This press is controlled remotely and

also connected to the common heating and cooling and vacuum lines. Molds are available in a large variety of sizes from 19.05 mm. (0.750 in.) to 50.8 mm. (2.0 in.) in diameter. Special molds available are:

Do-Nut molds 25.40, 27.66, 29.03 and 34.85 mm. (1.000, 1.089, 1.143 and 1.372 in.) diameters.

With cupped ram or heel 28.45 to 52.58 mm. (1.120 to 2.070 in.) diameters.

Spherical molds 38.10 to 81.0 mm. (1.500 to 3.189 in) diameters.

For booster cups 29.72 mm. (1.170 in.) diameter.

All booster and secondary explosives can be compacted on these presses including the PBX's. However, under safety regulations, the impact sensitivity limits the size of charges as follows: For pure explosives -

Sensitivity of 10 cm. or less - no more than 20 grams

Sensitivity of 11 to 15 cm. - no more than 250 grams

Sensitivity of 15 to 22 cm. - no more than 450 grams

With metal or abrasive in the compound:

less than 15 cm. - none

15 to 22 cm. - no more than 250 grams

These sensitivity values are obtained on the Bruceton type drop test machine, Figure 15, using a 2.5 kg. weight with the sample on 5/0 sandpaper. This test is described in detail in references (a) and (b). It is acknowledged that materials whose sensitivity falls in the range below 12 cm. are classed as initiators and should be handled with extreme care. However, some of these materials, because of other explosive properties, are considered as high explosives or as boosters. When the pressing of any such very sensitive material is required, consultation is held with the Branch and Division Chiefs and their approval is obtained before the work is begun. In general, it can be stated that it is dangerous to compact on a hydraulic press any material whose sensitivity value falls below 15 cm. on the impact scale.

Some explosives (such as RDX), will not make a good pellet, free of cracks and voids, without the addition of a small amount of wax or some other binder.

Pressing - Isostatic - Building 318

The isostatic press, Figure 3, has a pressure chamber 44.4 cm. (17.5 in.) diameter x 3.05 m (10 ft.) long. The bank of air operated pumps provide pressures up to 2,110 kg./cm.^{2} (30,000 psi) throughout the chamber. A good variety of flexible molds is available in sizes ranging from 2.5 to 40.6 cm. (1-16 in.) in diameter of various lengths to 45.7 cm. (18 in.).

All ordinary explosives have been pressed in the isostatic press. Moreover, with the temporary addition of 1 or 2% of solvent, some explosives which do not stay together after hydraulic pressing (such as RDX) have made good charges in the isostatic. Because there are no moving metal parts to the molds, danger from friction is minimized, and materials considered too sensitive for hydraulic pressing can be compacted here. While water is being used for the pressure medium the press may be heated to 100°C making possible the compression and curing of plastic-bonded explosives. By changing the medium to oil, the temperature limit can be increased to at least 130°C.

Machining - Building 318

Any solid explosive with an impact sensitivity higher than 20 cm. can be sawed, turned, milled, or drilled at Building 318. The Monarch Model 2013-16 Dyna-Shift air tracer lathe, Figure 4, will swing a 61 cm. (24 in.) diameter over the ways and 137 cm. (54 in.) piece between centers. The air tracer provides for turning any desired contour according to a given template. The spindle, and power longitudinal and transverse feeds, can be operated either directly or remotely. This lathe can also be operated conventionally without use of the air tracer. The South Bend Model A lathe, Figure 5, can swing a 33 cm. (13 in.) diameter over the ways and 20 cm. (8 in.) over the cross-slide. It takes a 137 cm. (54 in.) piece between centers, and may be started and stopped directly or remotely.

Two drill presses are available to this group. The Cincinnati-Bickford drill press, Figure 6, will accommodate work 53 cm. (21 in.) in diameter x 107 cm. (42 in.) long below the spindle to the base. The spindle travels 25 cm. (10 in.) and power feeds vary from 0.102 to 0.508 mm. per revolution (.004 to .020 inch per revolution). The spindle speed can be varied from 60 to 1,200 rpm. Starting and stopping can be done

directly or remotely.

The Walker-Turner pedestal drill press, Figure 5, also has adjustable automatic feed. Spindle speed can be varied from 400 to 2600 rpm. The distance from the base to the spindle is 91 cm. (36 in.), the chuck takes drills with shanks up to 12.7 mm. (1/2 in.) and remote operation is possible.

The Do-All Contour-matic "26" bandsaw, Figure 7, has a throat distance of 66 cm. (26 in.). It accommodates a work piece 30 cm. (12 in.) high, and powered table travel is 36 cm. (14 in.). This machine can be operated either directly or remotely.

All machines are equipped with a means of providing a stream of liquid coolant to the point of contact of the tool and the work. During remote operation there is a 46 cm. (18 in.) reinforced concrete wall between the operator and the machine. An adequate supply of hand tools, chucks, collets, jigs and fixtures is kept at hand so that all the usual, and some unusual machine jobs can be done on most types of high explosives.

Mixing, Blending, Drying

On a laboratory scale any explosive or propellant material may be mixed or dry-blended, filtered, dried, pulverized, and screened with available equipment. This equipment includes 1 gallon (3.785 liters) and 2 gallon (7.571 liters) Patterson-Kelley V-shell blenders, sigma type mixers, kettles, filters, trays, vacuum drying ovens, Figure 9, micro-mill, etc. Precision weighing equipment, Figure 8, enables the operator to make accurate mixes, dry to constant weight, obtain density, etc.

Propellant Formulation

Personnel and equipment are available in this group for the research on, and the preparation of solid, composite propellants. For problems in research, laboratory space is available with glass equipment, reaction vessels, mixers, explosion-proof hoods, a nitrogen dry box, and electric ovens, etc.

For preparation of propellants, such as the polyvinyl chloride type, polyurethane propellants, nitrasol formulations, and the polysulfide variety, all the necessary equipment is available for mixes on a laboratory scale. This equipment includes a .47 liter (1 pt.) Atlantic Research Corporation sigma mixer, Figure 11. This mixer is jacketed and equipped for vacuum mixing with remote control.

There is also a 3.8 liter (1 gal.) J.H. Day jacketed sigma mixer equipped with immersion heater and thermostat, and a thermocouple well in the bowl. It is equipped for vacuum mixing and is driven by a variable speed motor.

An apparatus constructed of tempered glass, Figure 12, is available for deaerating and vacuum casting propellant batches of up to 1.4 kg. (3 lb.). The propellant is deaerated through slits and vacuum cast directly into the mold, generally from the bottom. Charges up to 4.5 kg. (10 lb.) may be cast in this equipment by processing a part at a time. This apparatus can be heated for casting at elevated temperatures.

Three types of curing and drying ovens, Figures 9 and 13, are available. An electric oven with a temperature range of 45° to 280°C has a capacity of 45.7 cm. (18 in.) cube. Several steam heated ovens provide a temperature range of 45° to 95°C with circulating air. Steam heated vacuum ovens, Figure 9, are also available with a temperature range of 45° to 95°C. The capacity of these steam ovens is approximately 61 x 61 x 91 cm. (2 x 2 x 3 ft.).

Inspection and Testing

Very often our technicians are called upon to machine explosives to intricate shapes and tolerances of 0.025 mm.(0.001 in.).

The Kodak contour projector, Figure 10, enables one to check these shapes very accurately. It has a 76.2 cm. (30 in.) screen. Table travel is 20.3 cm. (8 in.) both horizontally and vertically. By use of the micrometer and dial indicator settings, measurements may be made in both directions precisely to 0.0025 mm. (0.0001 in.). Angles may be measured accurately to 1 minute. Front surface illumination allows measurement to intermediate points (inside the silhouette). There are three magnifications: 10x, 31-1/4 x, and 62-1/2 x.

Beside this very valuable machine the inspection equipment includes:

A 61 mm. (24 in.) square surface plate.

15.2 x 15.2 cm. (6 x 6 in.) angle plate.

15.2 cm. (6 in.) sine plate.

Johansson sine bar.

45.7 cm. (18 in.) Starrett vernier height gauge.

A 150 pka X-ray machine is assigned to this group, and larger machines are on the base.

Impact sensitivity values can be obtained on any type of explosive material by the use of the Bruceton type drop test machine, Figure 15. This apparatus and test procedure are described in reference (a) and the interpretation of the results is explained in reference (b).

Facilities are available for wax gap booster sensitivity test as outlined in reference (c).

A gun is available in Building 332 for carrying out bullet sensitivity tests in the bomb-proof Building 331, Figure 14.

References

(a) NavOrd Report 3592, Factors Affecting the Behavior of Explosives to Mechanical Shock, G. Svadeba, 18 December 1953. (Confidential).

(b) AMP Report No. 101.1R, Statistical Analysis for a New Procedure in Sensitivity Experiments, Statistical Research Group, Princeton University, July 1944.

(c) NavOrd Report 2370, Booster Sensitivity Investigations during the Period from July 1949 to March 1952, C. Lovenberg. (Confidential).

FIG I VACUUM CASTING KETTLE

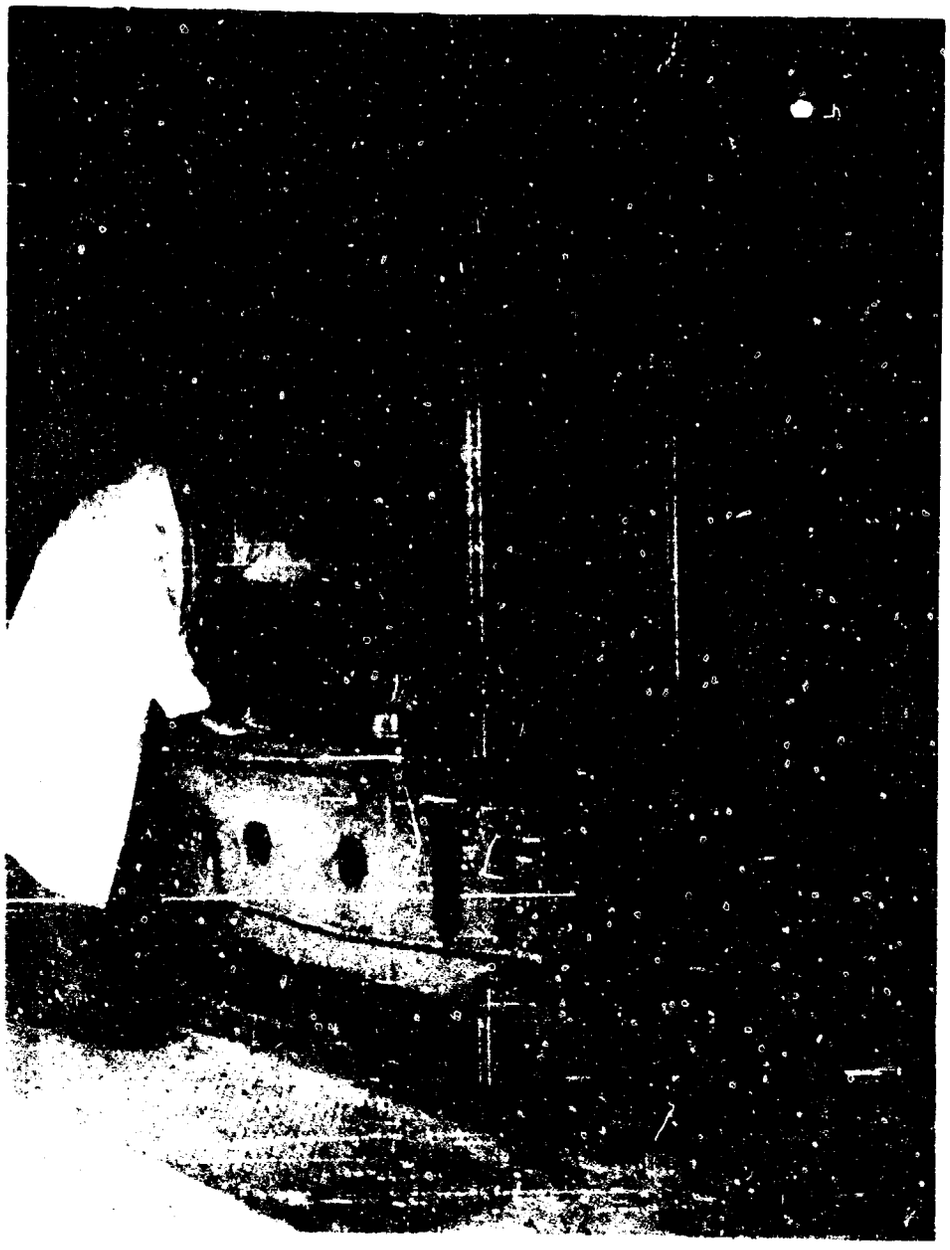


FIG. 2 300 TON HYDRAULIC PRESS

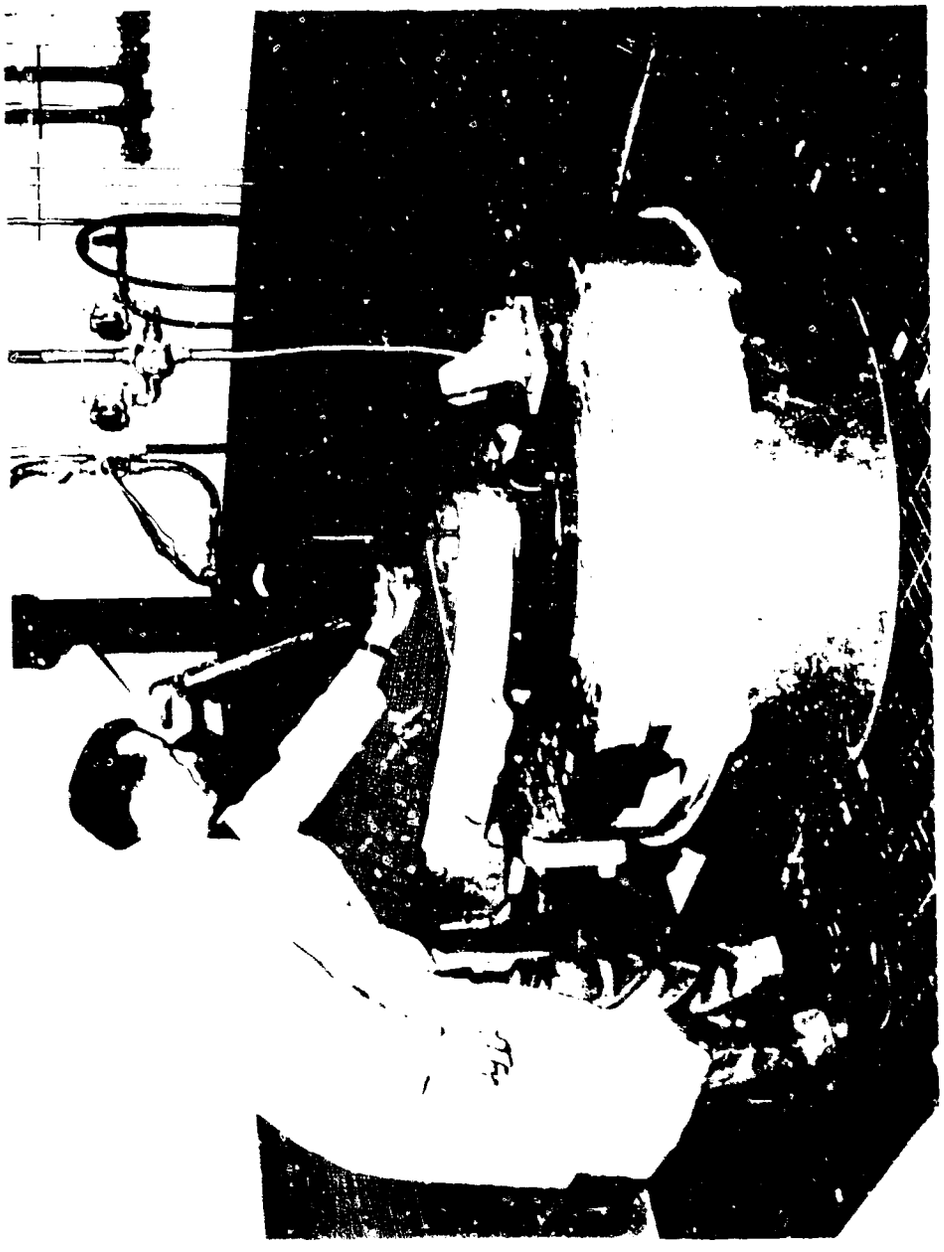


FIG. 3 ISOSTATIC PRESS

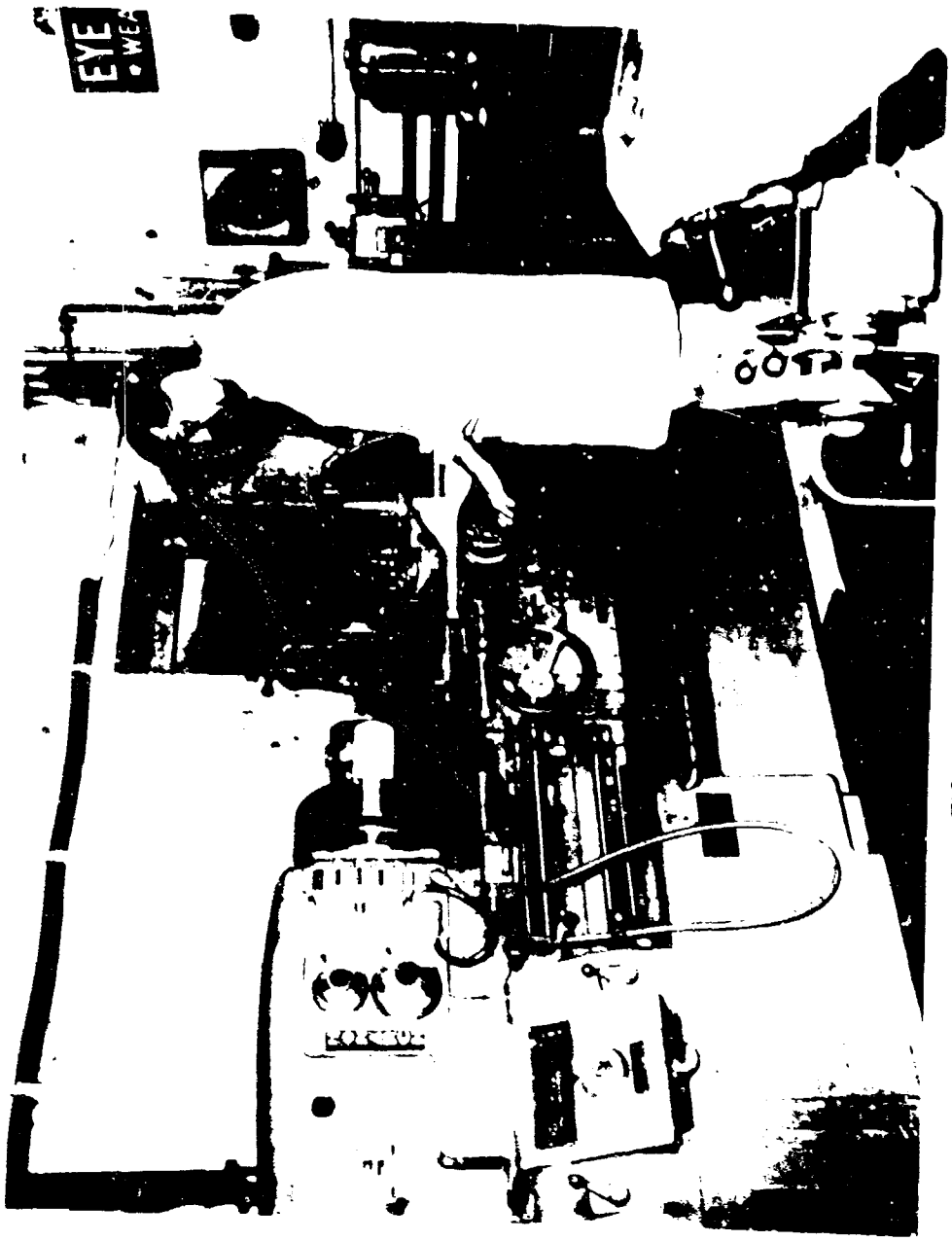


FIG. 4 AIR TRACER LATHE

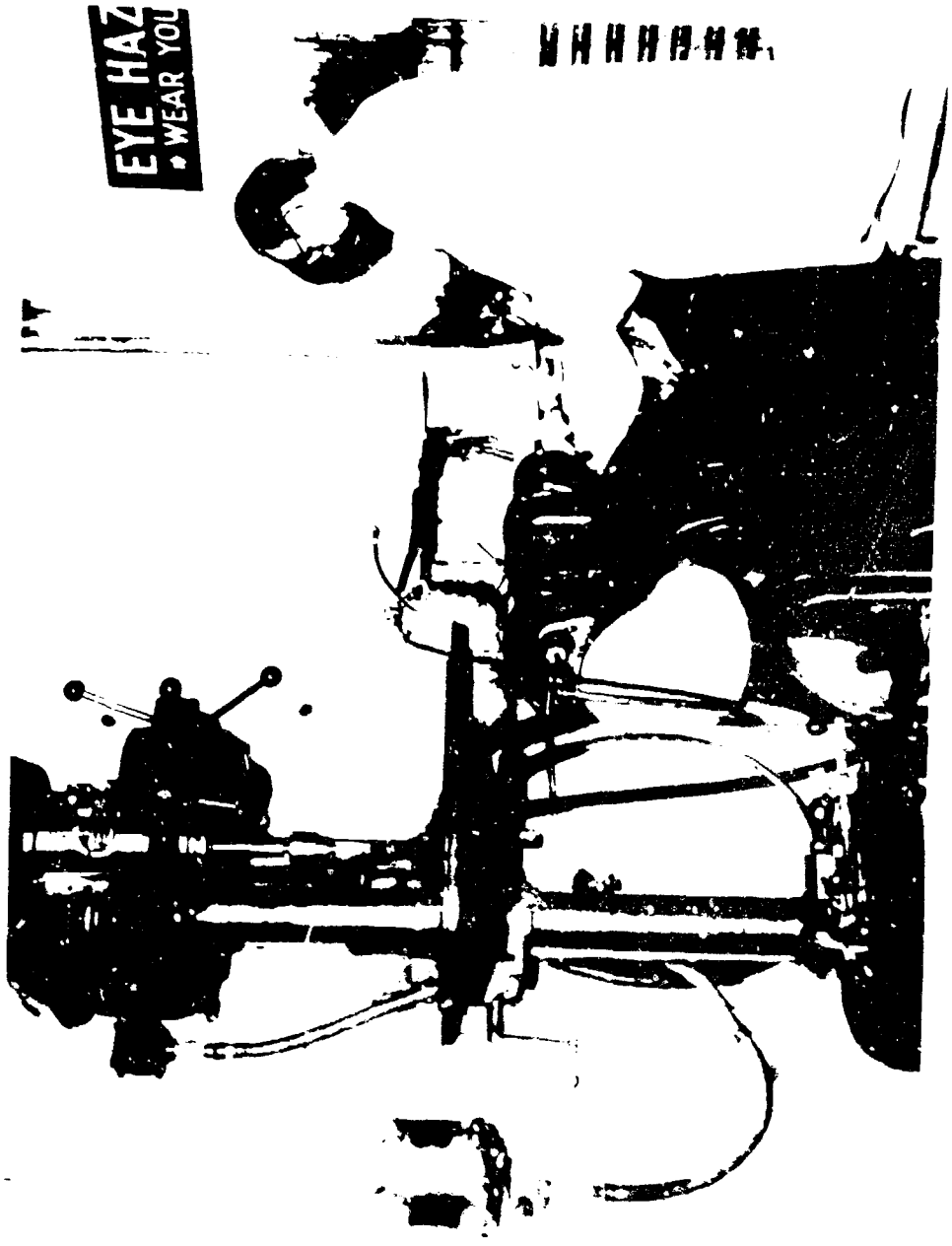
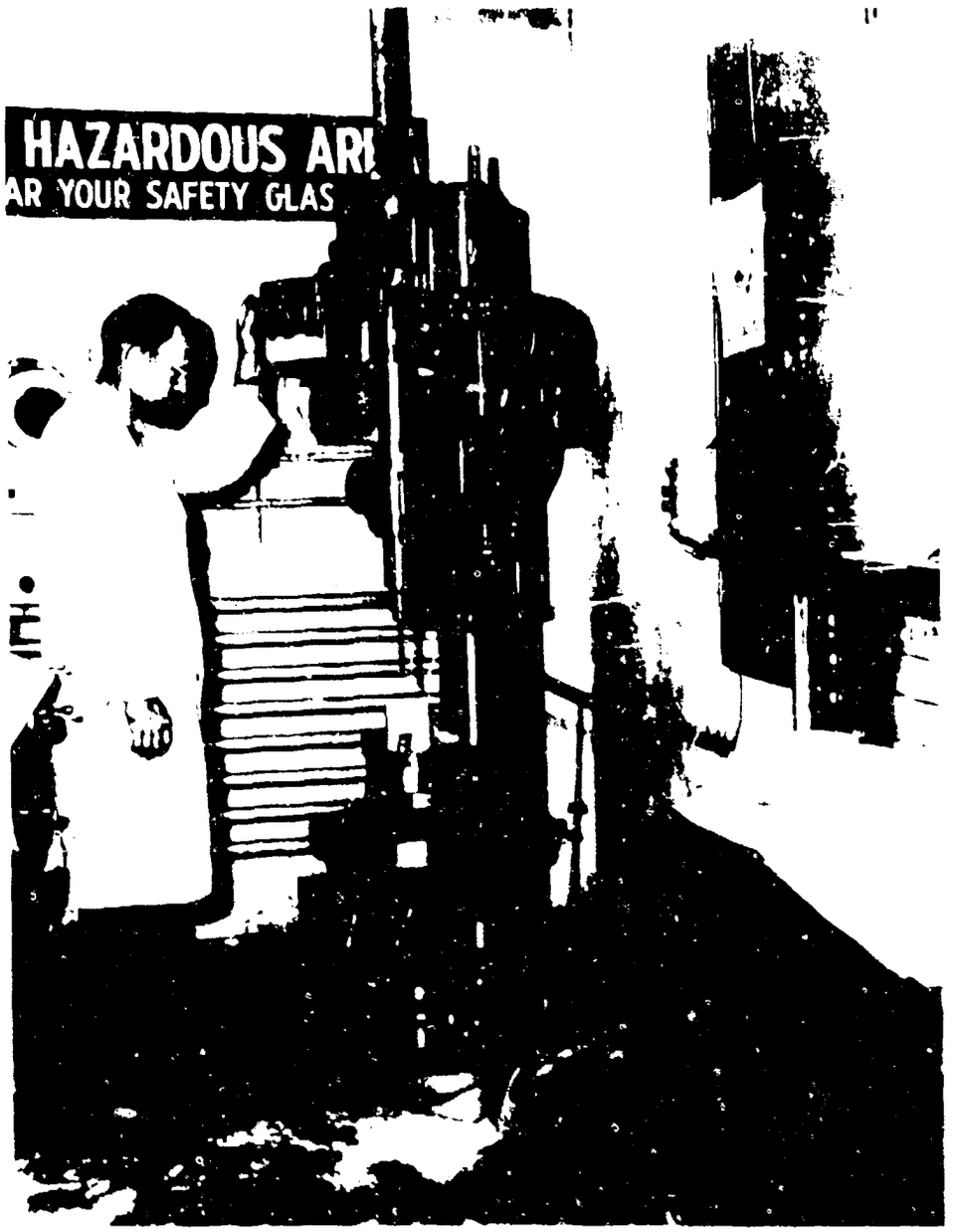


FIG. 5 LATHE AND DRILL PRESS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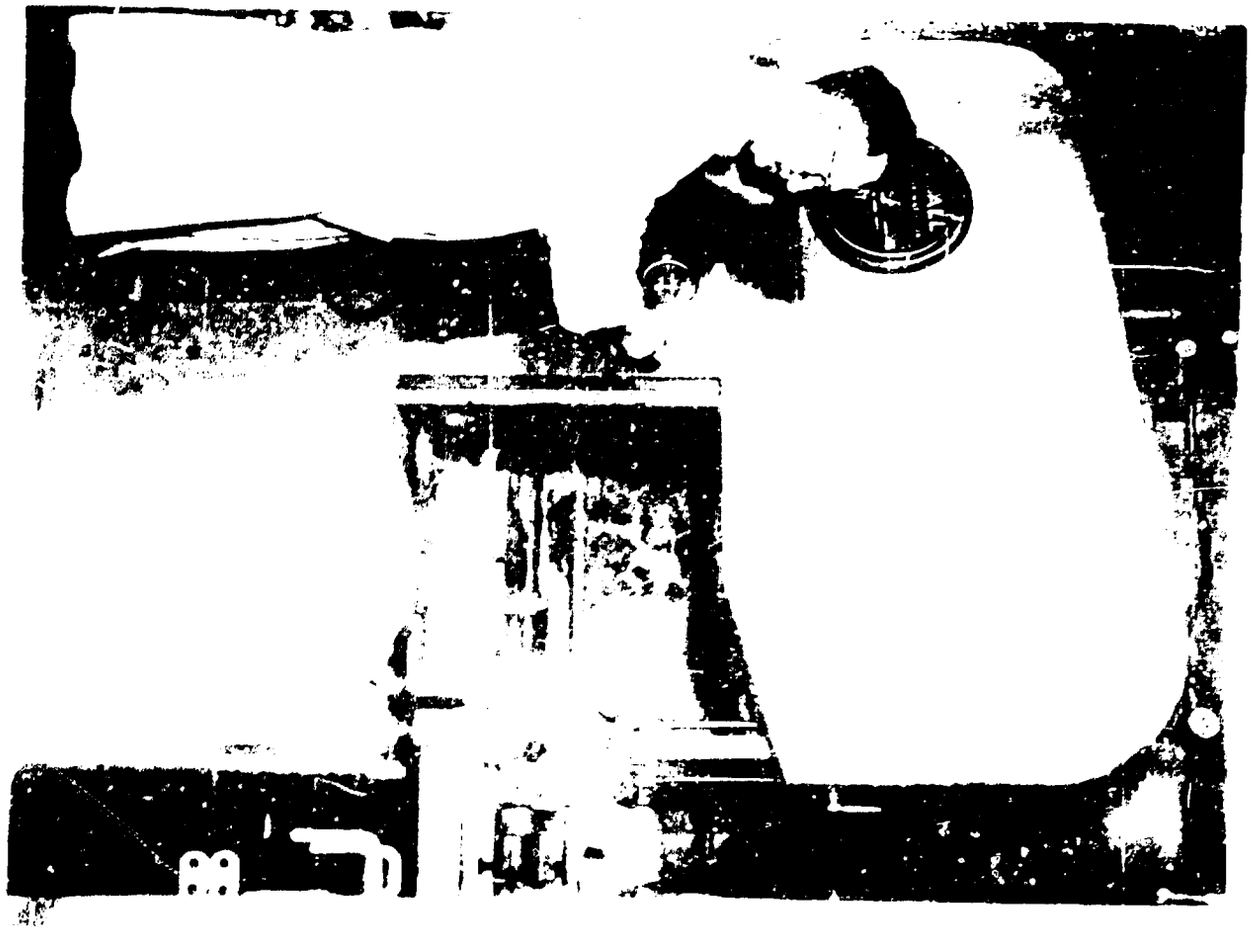
AR YOUR SAFETY GLAS



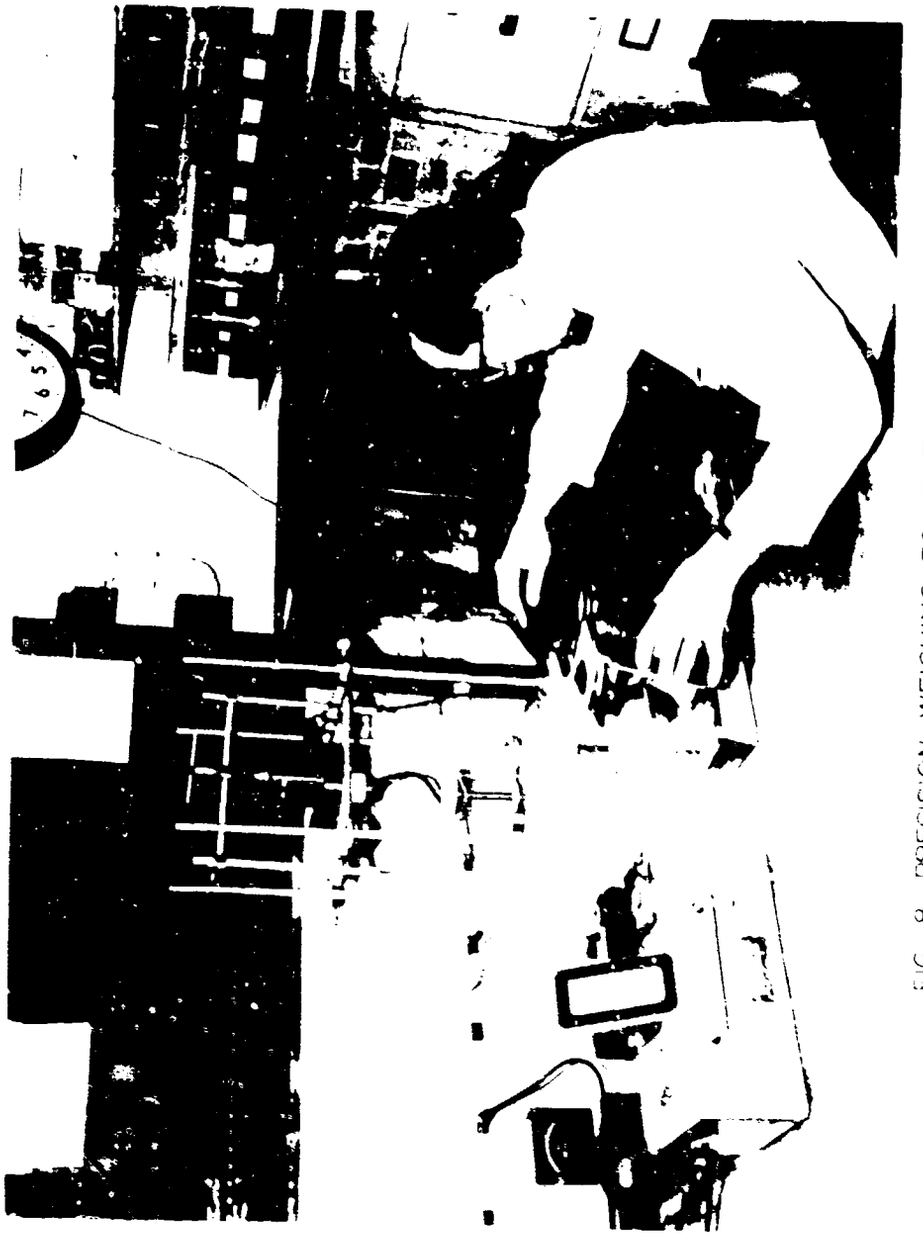


FIG 8 PRECISION WEIGHING EQUIPMENT

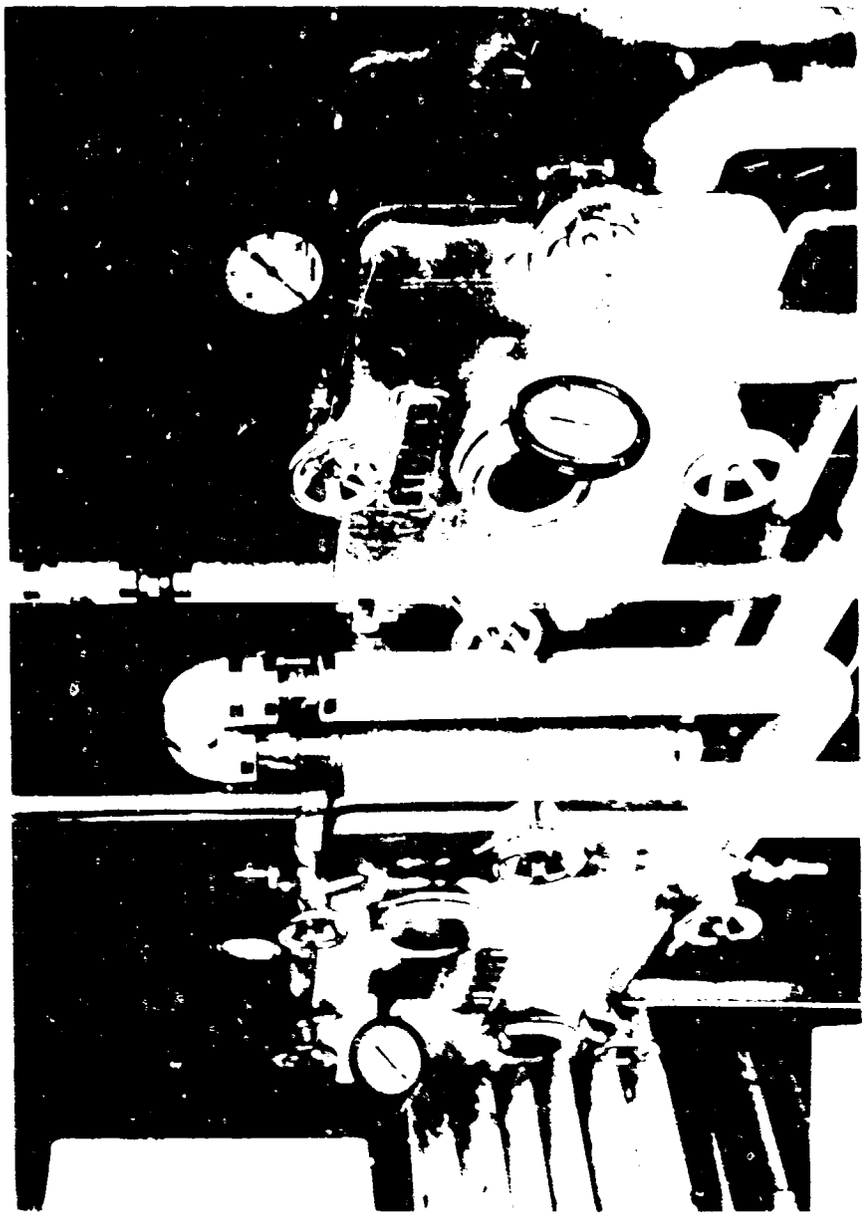


Fig. 9 VACUUM DRYING OVENS

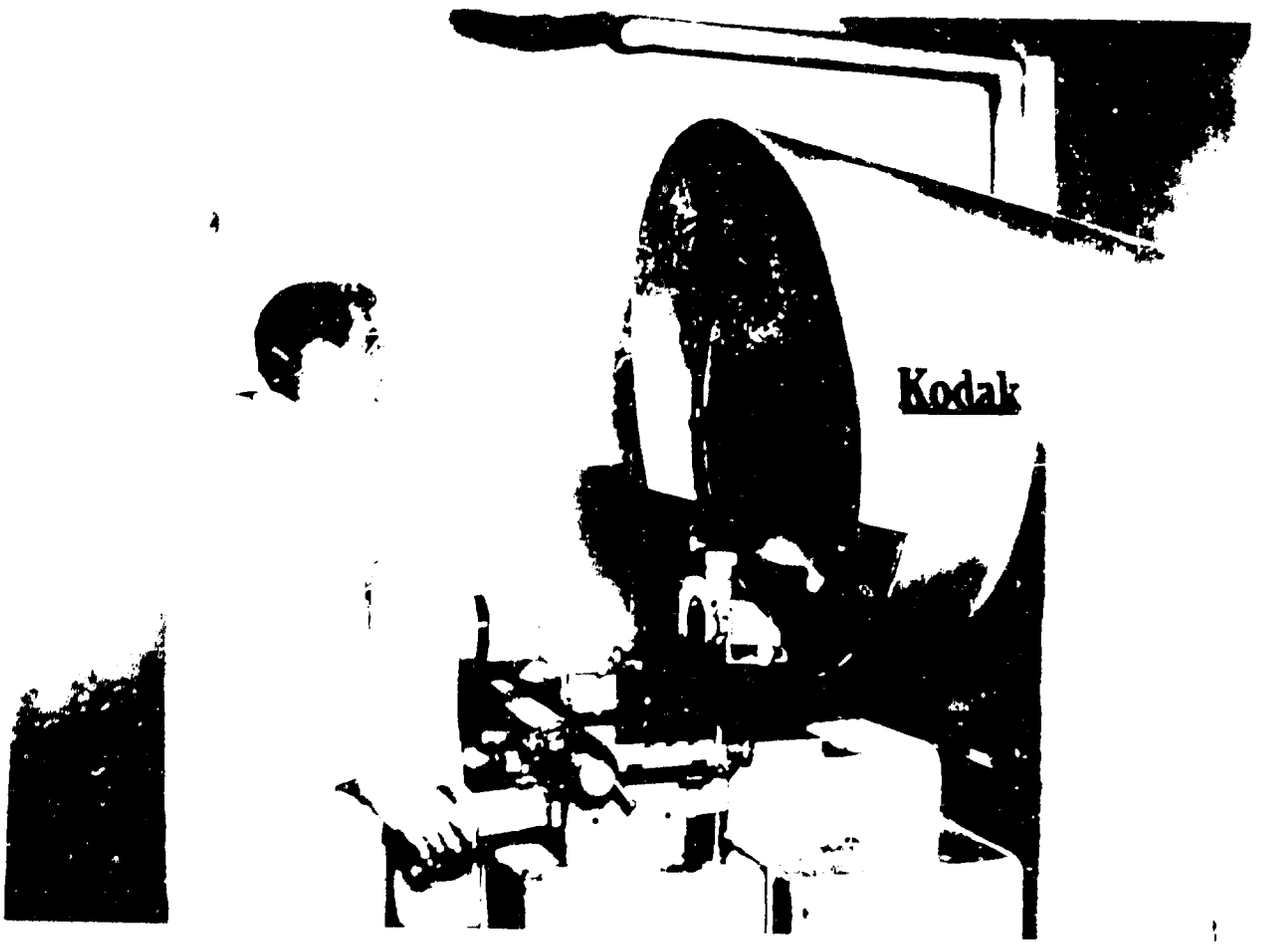


FIG. 10 CONTOUR PROJECTOR

FIG. 11 SIGMA MIXER

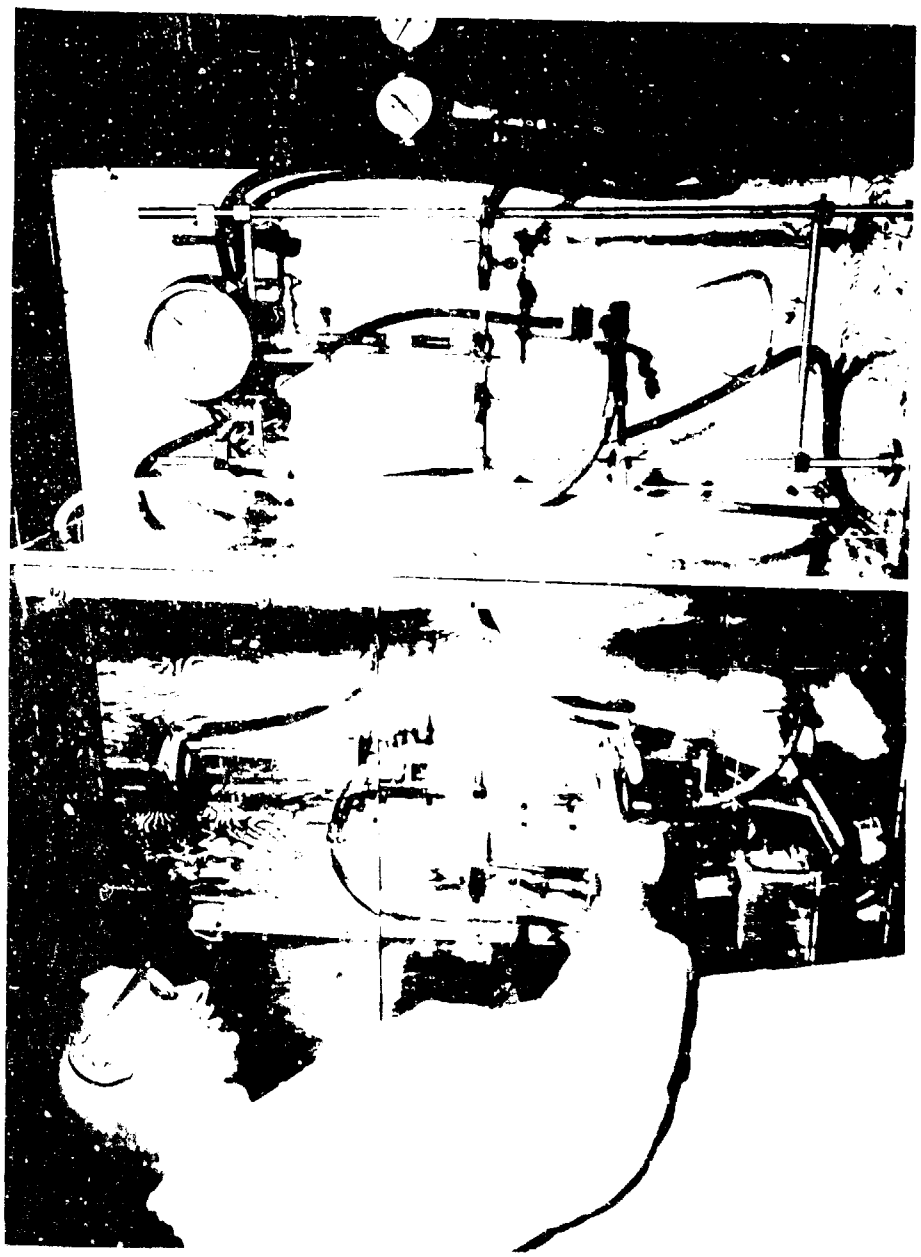


FIG. 12 DEACRATION EQUIPMENT

FIG. 13 DRYING OVEN

FIG. 13 DRYING OVEN

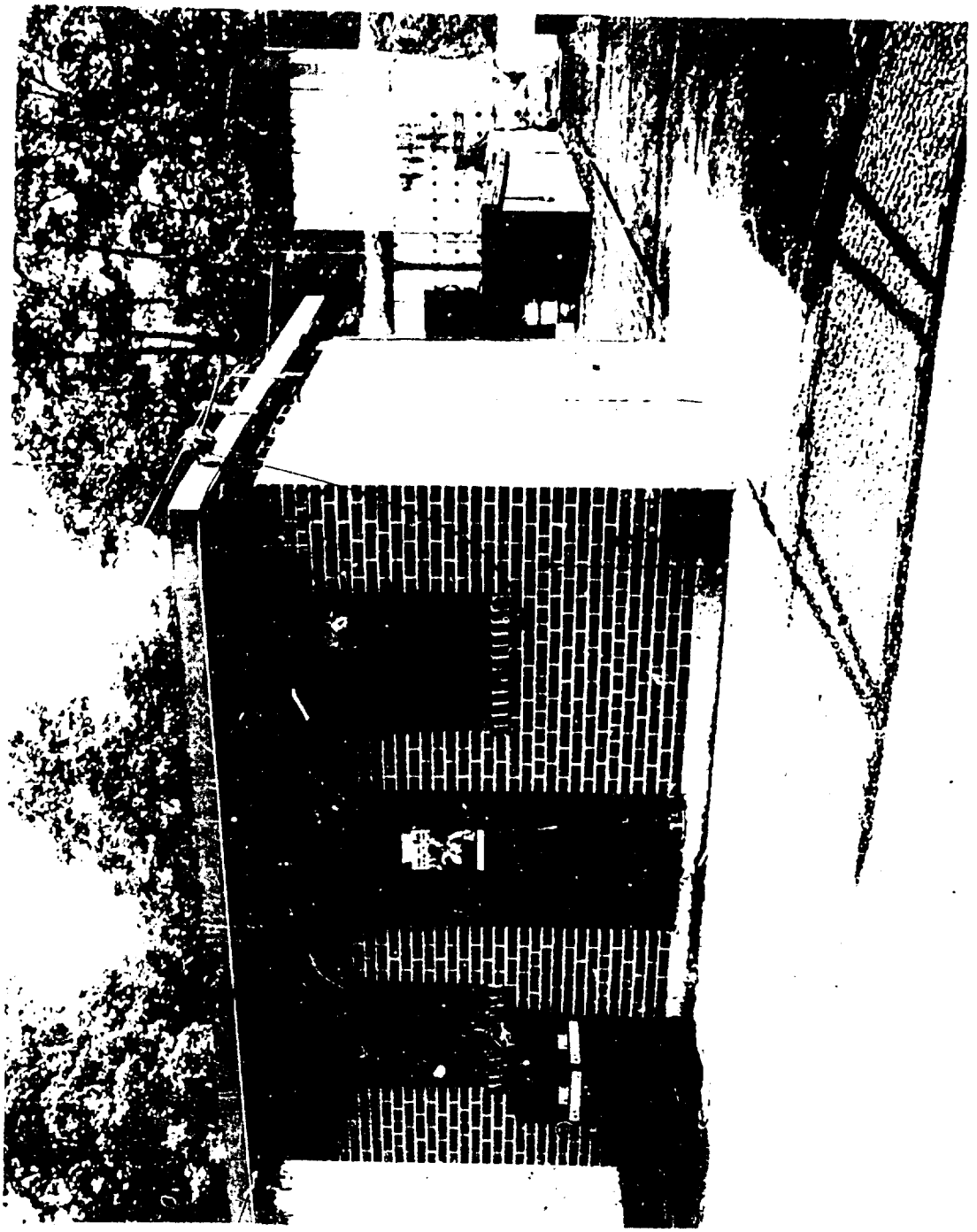


FIG. 14 BOMB PROOF

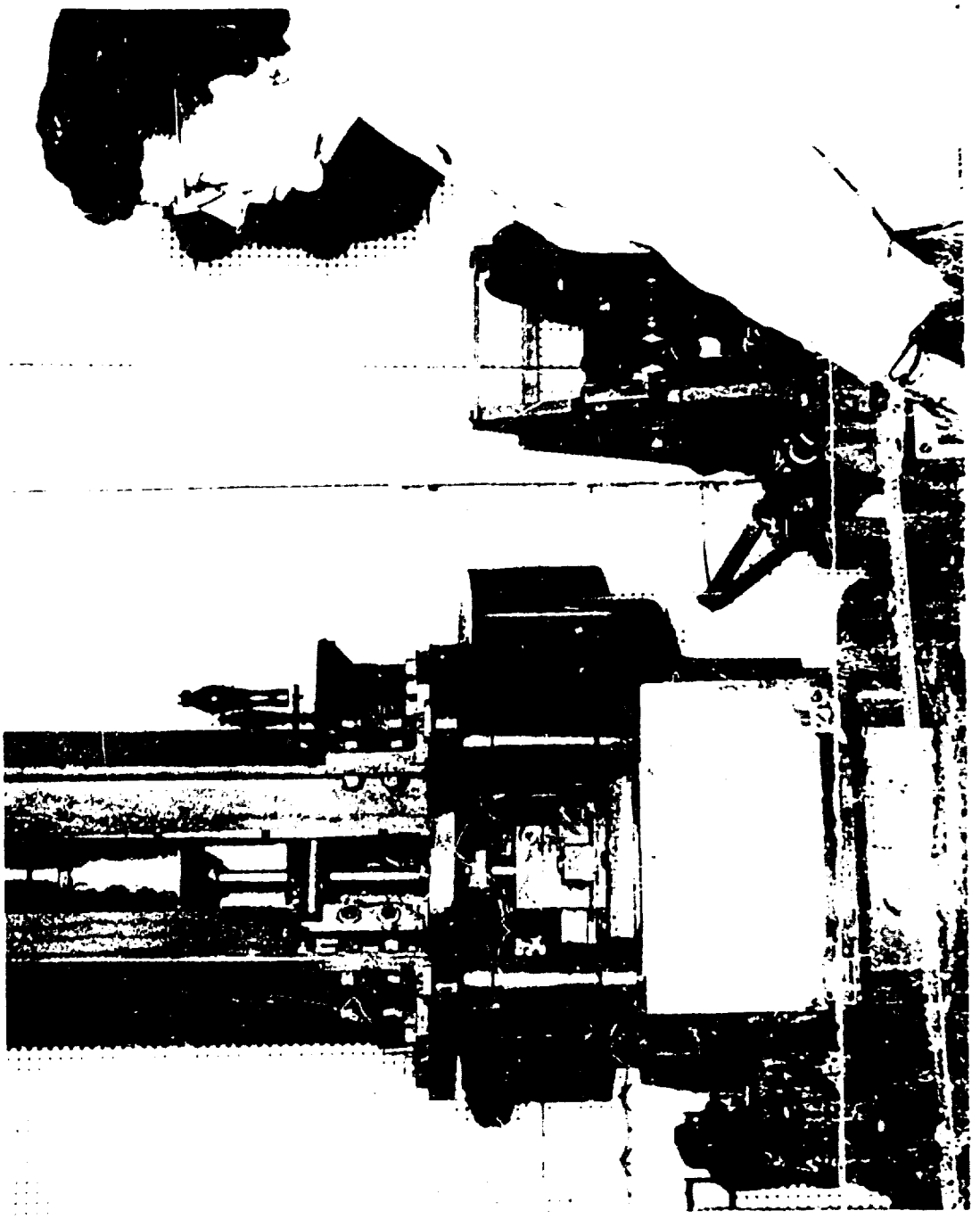


FIG. 13 BRUCETON DROP TEST MACHINE